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AN EMPIRICAL INVESTIGATION INTO THE EFFECT OF BETA FREQUENCY BINAURAL BEAT AUDIO SIGNALS ON FOUR MEASURES OF HUMAN MEMORY

by Richard Cauley Kennerly, MA

Richard Cauley Kennerly is currently the director of clinical services for an adolescent treatment center in metropolitan Atlanta, Georgia. He will begin doctoral studies this fall in behavioral medicine. Rick has a keen interest in effective nondrug therapies, neuronal regulation, means of accessing full human potential, and "in general, everything under the sun." His research was a direct outgrowth of his insatiable thirst for knowledge. After what he describes as a lifetime of academic struggle, Rick discovered that a combination of nutritional supplementation and binaural beat signals could offset his learning disabilities. Learning finally became a pleasure. This thesis arose from his personal success with and interest in binaural beat signals.

IN THIS ISSUE

Anecdotal reporting has consistently supported Hemi-Sync's value for creating optimal learning environments and facilitating mental focus. Richard Cauley Kennerly, MA, applied empirical methods to investigating these observations. It is our pleasure to devote this issue to a condensed version of his 1994 thesis, which was presented to the graduate faculty of West Georgia College in partial fulfillment of the requirements for a master's degree in psychology.

Introduction

This study is an empirical inquiry into the facilitation of human memory with the use of beta frequency binaural beat audio signals (BBSs) under conditions designed to control for confounding variables. Previous studies have not controlled for confounding variables, preventing any definite conclusions on the extent to which BBSs may facilitate memory.

Statistically significant results in this study would support earlier nonempirical research which has found BBSs to be useful in facilitating improved academic performance among mainstream and attention deficit/hyperactive disorder (ADHD) populations. The results of the earlier studies, and more tightly controlled studies with other brain-wave training techniques, suggest that beta frequency BBSs should significantly facilitate memory.

Hypotheses, Dependent Variables, and Operational Definition of Memory

Four hypotheses were used, each postulating that in a study controlling for confounding variables the experimental group would display a statistically significant improvement in mean scores over the control group at a .05 or less significance level.

Hypothesis one (H_1) postulated a statistically significant higher mean score for the experimental group as measured by a twenty-five-item word list recall test. This first test was a simple free recall memory task.

Hypothesis two (H_2) postulated a statistically significant higher mean score for the experimental group as measured by a twenty-five-item word list recall/recognition test. This test was a German vocabulary combined recall/recognition test given to obtain data on the facilitation of memory with a more complex associative recall/recognition task.

Hypothesis three (H_3) postulated a statistically significant higher mean score for the experimental group as measured by the Welscher Adult

Intelligence Scale (WAIS-R) digit symbol subtest.

Hypothesis four (H_4) postulated a statistically significant higher mean score for the experimental group as measured by the WAIS-R digit span subtest.

The third and fourth tests were administered in order to gain clarity on the observations of teachers who have reported improvements in grades, student attention, and decreased hyperactivity while using binaural beats in their classes. Facilitation of the ability to attend and persevere at routine tasks may be in part, or in whole, the underlying factor in the facilitation of memory by binaural beat signals.

Statistically significant improvement in the mean scores of the experimental group over the control group on any of the tests allows one to infer that facilitation of test performance occurred. In the absence of confounding variables, this facilitation of test performance can be attributed to the independent variable.

The free recall word list test and the combined recognition/recall test are the two most memory-related tasks out of the four presented and thus the two most relevant to drawing any conclusions about the facilitation of memory. For the purposes of this study, memory was operationally defined as a subject's ability to reproduce on a test, within the time allocated, the information presented on each of four subtests.

Review of Related Literature

A quiet revolution has been occurring in the study of human cognitive functioning and its associated brain-wave activity. New interventions have arisen out of ongoing research in electroencephalographic (EEG) feedback. Utilizing this information, biofeedback researchers have been training subjects who have frequency patterns associated with various disorders to alter their brain-wave patterns to match those associated with normally functioning individuals. This approach has been found to be a rapid and effective intervention for many severe and resistant pathologies including depression, sleep disorders, seizures, chronic fatigue, headaches, mood swings, anxiety, alcoholism, addiction, ADHD, epilepsy, post-traumatic stress, paralysis, and cognitive impairment as a result of a stroke or head injury.

Possible Mechanisms Underlying Brain-wave Training

Different neurotransmitters are triggered by different frequencies and wave forms. The implication is that the brain's neurochemistry, and thereby its functioning, can be altered with modifications of brain-wave frequency. There is also speculation that the neurochemical response to trauma may become entrained as a permanent state and that brain-wave training may allow a return to the pre-trauma neurochemical state.

Perhaps the most famous research to date using EEG biofeedback training has been the work of Peniston and Kulkosky, developers of the Peniston protocol. Alpha-theta brain-wave training was used to increase the amount and amplitude of [alcoholic] subjects' alpha and theta brain waves. The control group, who received traditional medical treatment, demonstrated an 80 percent relapse rate during the thirteen-month post-treatment follow-up period. The experimental group, who received fifteen twenty-minute brain-wave training sessions (and no other treatment) demonstrated only a 20 percent relapse rate during the same period.

Other researchers have investigated the benefits of brain-wave training for beta frequencies. In a controlled study, Dr. Siegfried Othmer found that beta training produces average IQ increases of 23 percent. Where the starting IQ value was lower than 100, the average IQ increase was 33 points. Brain-wave training might actually increase the level of functioning of an unimpaired subject.

Unfortunately, financial resources limit the availability of EEG biofeedback brain-wave training. It is hard to imagine a classroom with all twenty students seated, with electrodes on their heads, and a biofeedback therapist attending to each of them. Fortunately, EEG biofeedback training is not the only way to accomplish the EEG training.

Audio and visual driving of brain-wave frequencies without a feedback loop has been found to be an effective method of performing brain-wave training, and cranial electrical stimulation introduces the desirable frequencies by low-level electrical currents applied to the cranium.

There is another cost-effective method of conducting brain-wave training: binaural beat audio signals. Only sound driving is used to alter brain waves and, in specific forms of intervention, selected frequencies can be presented. By using audio stimulation only, equipment is reduced to a tape and personal stereo tape player. Access may also be provided by open air speakers, relieving the subjects from having to wear any equipment at all.

Variables in This Study

The independent variable was the presence of BBSs on the instrumental music tape for the experimental group and the absence of BBSs on the same instrumental music tape heard by the control group. The four dependent variables were the tests administered to fifty undergraduate students of West Georgia College, most of whom participated for extra credit or to meet a course requirement. A between-groups design, also known as an independent subject design, was used in the study. Subjects were randomly assigned with a double-blind methodology (by a coin toss) to experimental and control groups. A .05 or less significance level was used to determine whether or not to accept the null hypothesis ($p>.05$) or reject it ($p<=.05$) in favor of the research hypothesis. The experimental group contained twenty-seven subjects who were presented with a music tape bearing binaural beat audio signals while performing four different learning tasks. The control group contained twenty-three subjects who performed the same four learning tasks as the experimental group. The music tape that the control group listened to did not contain the BBSs but was otherwise identical to the experimental group's tape. The two tapes were provided by The Monroe Institute. They were presented via headphones and a stereo tape player. The researcher controlled the sound level to prevent possible confounding of the results by variations in volume.

At the time of data collection, neither the experimenter nor subject knew which tape was for the experimental group and which was for the control group.

In order to counterbalance any effect of practice or fatigue, the four learning tasks were presented on a rotating basis known as Latin squares to insure the even distribution of any carryover effects from one learning task to another.

Each subject completed a consent form in compliance with the West Georgia Institutional Review Board procedure for research with human subjects. It was explained that the purpose of the experiment was to determine what effect, if any, listening to these tapes at a low volume has on memory tasks, that the tapes did not contain any subliminal messages, that there would be four separate memory tasks, and that the whole process should take no more than forty-five minutes. The results of the study and personal scores were available to subjects after the study was completed.

At the time of data collection, neither the experimenter nor subject knew which tape was for the experimental group and which was for the control group. Once a subject was assigned to a group, the appropriate tape was placed in the tape player, and the subject was asked to listen to the tape for fifteen minutes. This allowed time for entrainment of the

brain waves of the subjects in the experimental group. Subject numbers were placed on the front of the test packets, which were also marked for the sex of the subject, position in Latin square rotation, and group.

At the end of the fifteen minutes of listening to the tape, each subject was instructed to continue listening to the tape during each of the four subtests. Each learning task was presented in the most uniform manner possible.

Scoring of Tests

The word list recall and the German vocabulary recognition/recall tests were scored with one point being assigned for each correct answer. The digit symbol and digit span subtests of the WAIS-R were scored and scaled before being analyzed, in accordance with the procedures outlined in the WAIS-R manual.

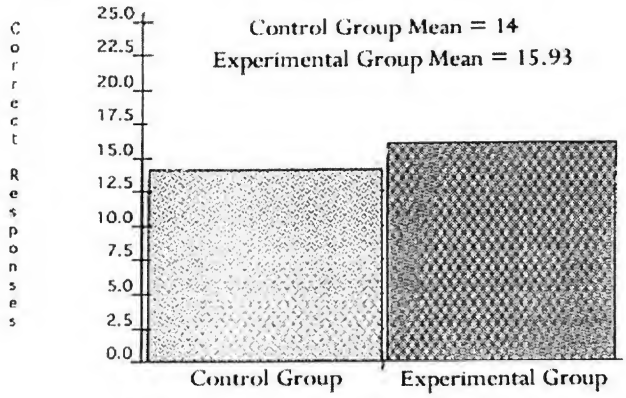
Limitations

To eliminate confounding variables, a simple post-test-only design was employed. Each subject was seen in a single interview to be assigned to a group, to be exposed to one of the two levels of the independent variable, and finally to have the effect of the independent variable measured. While this design maximized the isolation of the independent variable, there was no opportunity for it to exert a cumulative effect upon the dependent variable. This is an important limitation. Peniston and Kulkosky noted, "Time course analysis of the EEG effects of brainwave training revealed that increases in alpha and theta rhythms occurred gradually across the fifteen treatment sessions." Studies evaluating student performance over a period of weeks or months have also had the benefit of the cumulative effect. A logical next step might be to repeat this study with a longitudinal dimension to observe any increase in performance across sessions and to observe the effect of binaural beat audio signals on learning as well as memory.

Placebo and suggestion effects were deliberately filtered out by the double-blind design. If some of the positive results of previous studies resulted from just such effects, the positive results of this study may not be as profound.

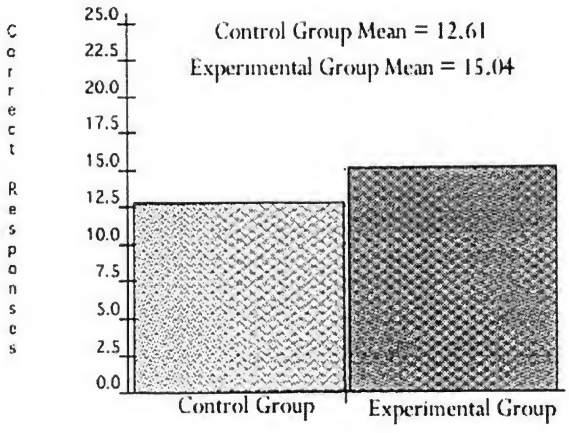
Results

The experimental group displayed statistically significant higher mean scores on three of the four dependent measures, allowing for the rejection of the null hypothesis for H_1, H_3, and H_4. The obtained data did not allow for the rejection of the null hypothesis with H_2. Figures 1 through 4 display the mean scores with histograms and significance level.



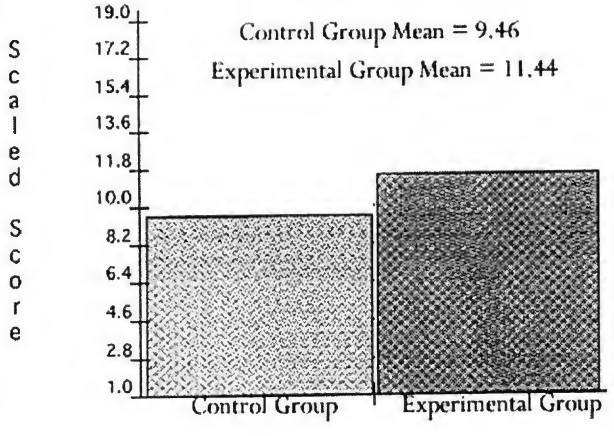
The Value of t (2.5) with 48 degrees of freedom, falls between a p of .02 and .01, and is considered to be statistically significant since p is less than .05.

Figure 1. Word List Free Recall Mean Scores



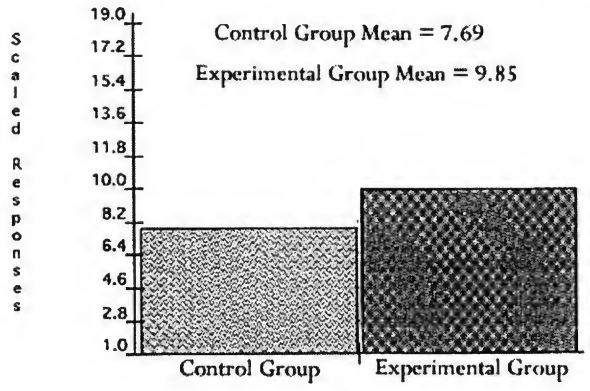
The value of t (1.76) with 48 degrees of freedom, falls betweeen a p of .10 and .05, and is not considered to be statistically significant since p is not equal to or less then .05.

Figure 2. Word List Recognition Mean Scores



The value of t (2.83) with 48 degrees of freedom, is greater than the critical value for a p of .01, and is considered to be statistically significant since p is less than .05.

Figure 3. Scaled Digit Symbol Mean Scores



The value of t (2.4) with 48 degrees of freedom, falls between a p of .02 and .01, and is considered to be statistically significant since p is less than .05.

Figure 4. Scaled Digit Span Mean Scores

Discussion

The data support facilitation of memory by binaural beat audio signals as measured by the word list recall test. The results of the digit span and digit symbol tests support reports of a decrease in student hyperactivity and an increased ability to pay attention in class while using BBSs. It is reasonable to infer, given the current data, that beta frequency BBSs are helpful for those individuals seeking help in free recall memory, attention, and completion of routine tasks.

The word list recall is a simple free recall test and thus was considered by the experimenter to be the core dependent variable for examining any facilitation of memory with binaural beat audio signals.

The German vocabulary recognition list is more of a combined free recall and cued recall task. Surprisingly, the results for this subtest did not show a statistically significant increase in memory. Since a Latin square rotation of the tests was used, this is not a result of the order of presentation. Perhaps the associative memory mechanisms behind remembering the meanings for a novel set of words were not reinforced as strongly as the mechanisms behind the pure recall of a word list. None of the subjects knew German, and the chosen words did not resemble their English equivalents. Since previous work in the comparable task of second language acquisition has reported that BBSs improved performance, the lack of statistically significant mean scores in this case may be an artifact of the single session limitation. It would be interesting to see if the data from administering a foreign language vocabulary test would have a statistically significant outcome in a longitudinal study.

The digit span subtest indicates ability to recall and repeat back a series of rote numerical digits and also an individual's ability to attend.

The digit symbol test is timed. Heightened memory should facilitate higher scores due to less time spent going back to the list of symbols and their numerical equivalents. It is characterized as a performance subtest which measures the subject's ability to persevere at routine tasks.

Relation of Results to Previous Research

The results support the ability of BBSs to function as an effective, stand-alone form of brain-wave training. The research corroborates the observations of teachers who have reported better grades and fewer behavioral problems while utilizing binaural beat audio signals in the classroom. The data support the conclusions of previous research that binaural beat audio signals increase a subject's ability to perform free recall tasks, attend (reduced student distractibility), and persevere at routine tasks (as measured by the digit span and digit symbol subtests); three important dimensions for success in the classroom.

Recommendations

It would be rewarding to pursue the effect of binaural beat audio signals into broader applications. Of particular interest would be the use of binaural beat audio signals to help both ADHD and unimpaired students function at a higher level in mainstream classes. Another study seems to be in order to properly address the question of whether or not the BBSs can facilitate learning as well as memory. Finally, it would be of interest to investigate alpha-theta BBS brain-wave training in the treatment of alcoholism and drug abuse. If the results of such a study find comparable benefits to the Peniston protocol, then the social and educational impact would be wide-ranging.

Conclusions

Having found binaural beat audio signals to be an effective method of facilitating memory on three of the four dependent variables in this study, it may be inferred that they are a viable form of brain-wave training and could provide a portable, inexpensive method of assisting students and other individuals in memory tasks. This study suggests that the observed results with binaural beat signals in previous research were the result of the binaural beat signals and not the result of placebo effects or a confounding variable.

[You may download the complete text, with all references, from the World Wide Web at:
http://www.monroe-inst.com/research/human-memory-kennerly.html]

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